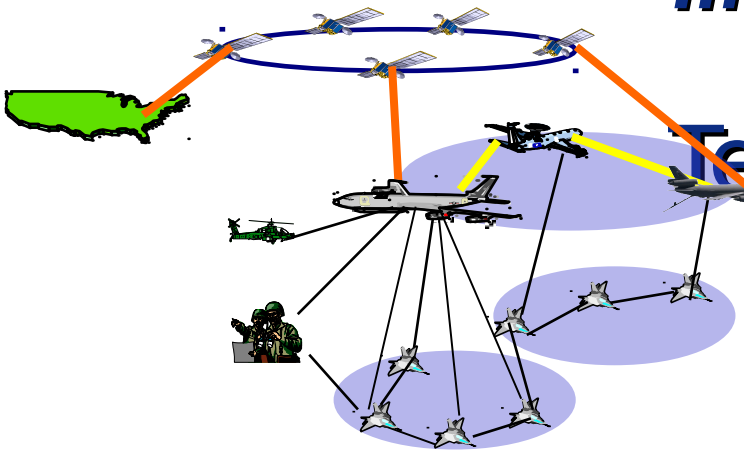
Network Centric Operations & Integration Systems Wing



Technical Challenges in Military Airborne Networking

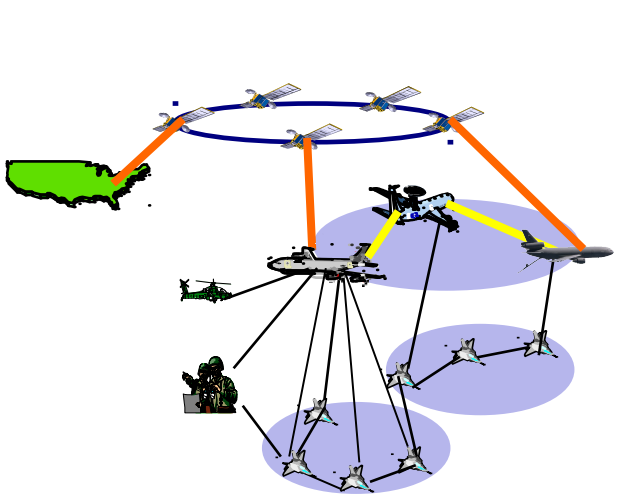
U.S. AIR FORCE

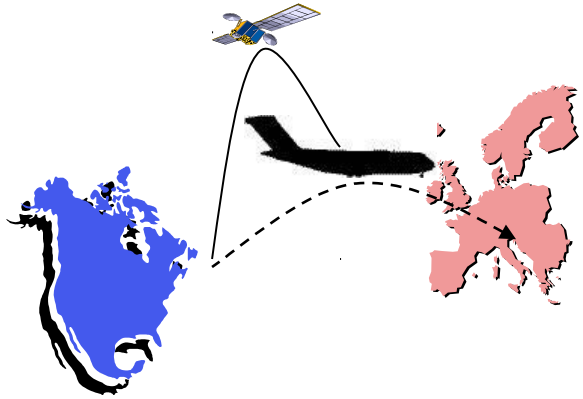
"POWER TO THE EDGE"

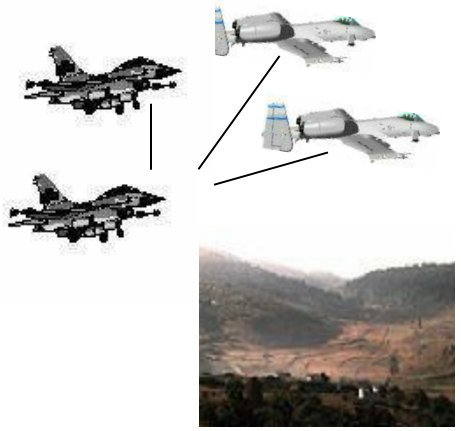
Overview

- **Airborne Network Architecture**
- Network Infrastructure Challenges
- Impact of Air-to-Air Link Performance
- Mobility Considerations
- Integration with Space and Surface Networks

Airborne Mission Profiles







Command & Control (C2) Constellation Configuration

- Global Strike Task Force in Persistence Phase
- Theater Mission
- Line of Sight of Many Nodes

En-Route Configuration

- Airlift En-Route to Theater
- B-2 En-Route to Theater
- Global Mission
- Beyond Line of Sight of Surface Nodes

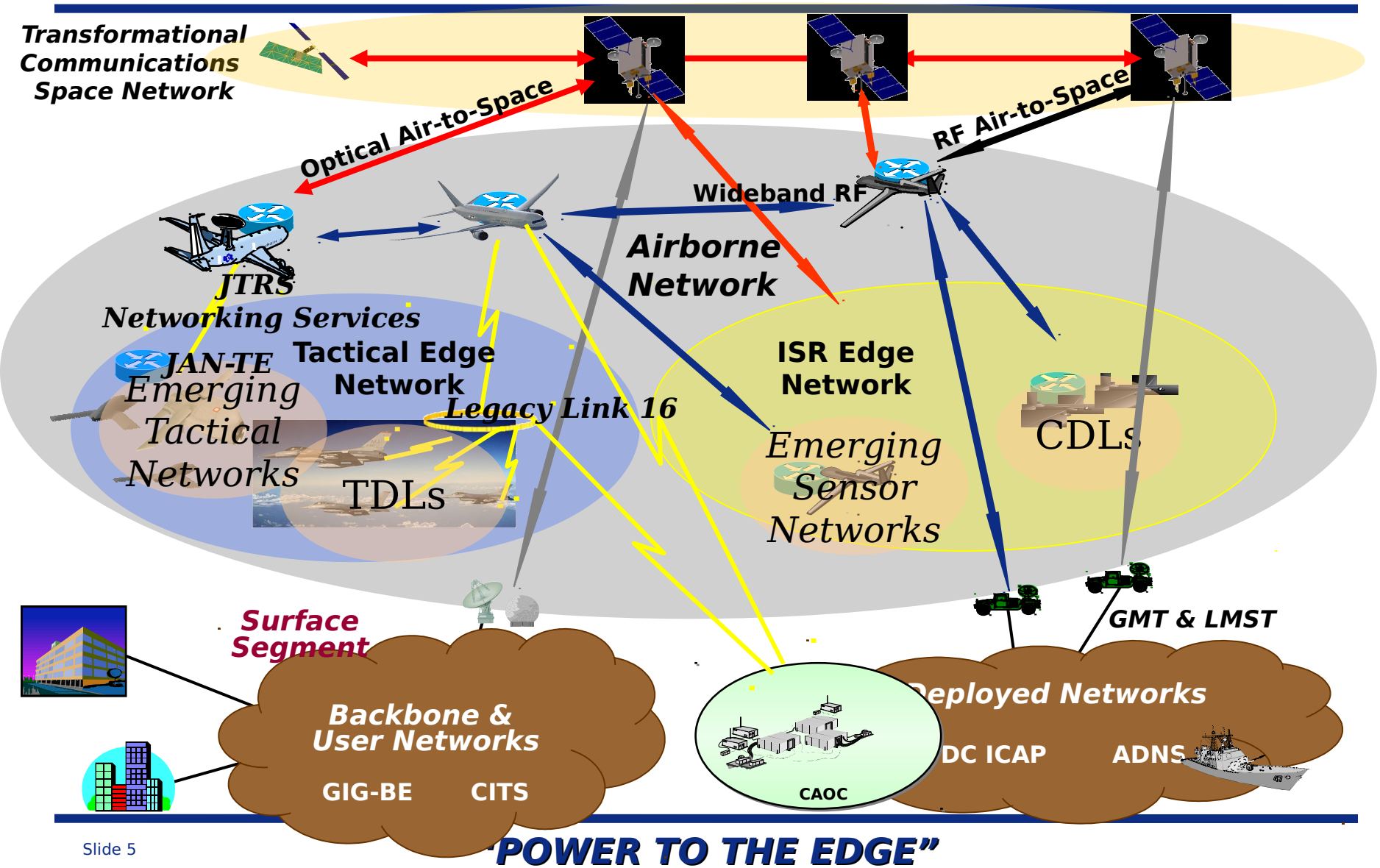
Strike Package Configuration

- Global Strike Task Force in Kick-Down-Door Phase
- Fighters, Attack, Bombers, Munitions
- Beyond Line of Sight of C2 Assets

The Airborne Network must satisfy a broad range of technical requirements

- **Network structure**
  - **Self-forming, self-organizing, self-healing**
  - **Fast formation and organization - join, leave, reorganize quickly**
- **Information Transport Performance**
  - **Very short transport latency to normal latencies to best effort**
  - **Assured delivery of information – delivered correctly within expected time period**
- **Special case - receive-only mode platforms**
- **Intra-network range**
  - **Line-of-sight as well as beyond-line-of-sight intra-networking**
- **Integration with the Global Information Grid (GIG)**
  - **AN will provide Joint airborne connectivity for USAF's ConstellationNet, Army's LandWarNet, and Navy's ForceNet**
  - **Needs to enable reachback connections anywhere on the GIG**
  - **GIG mandates (i.e., IPv6, XML) apply to the AN**

Airborne Network Vision



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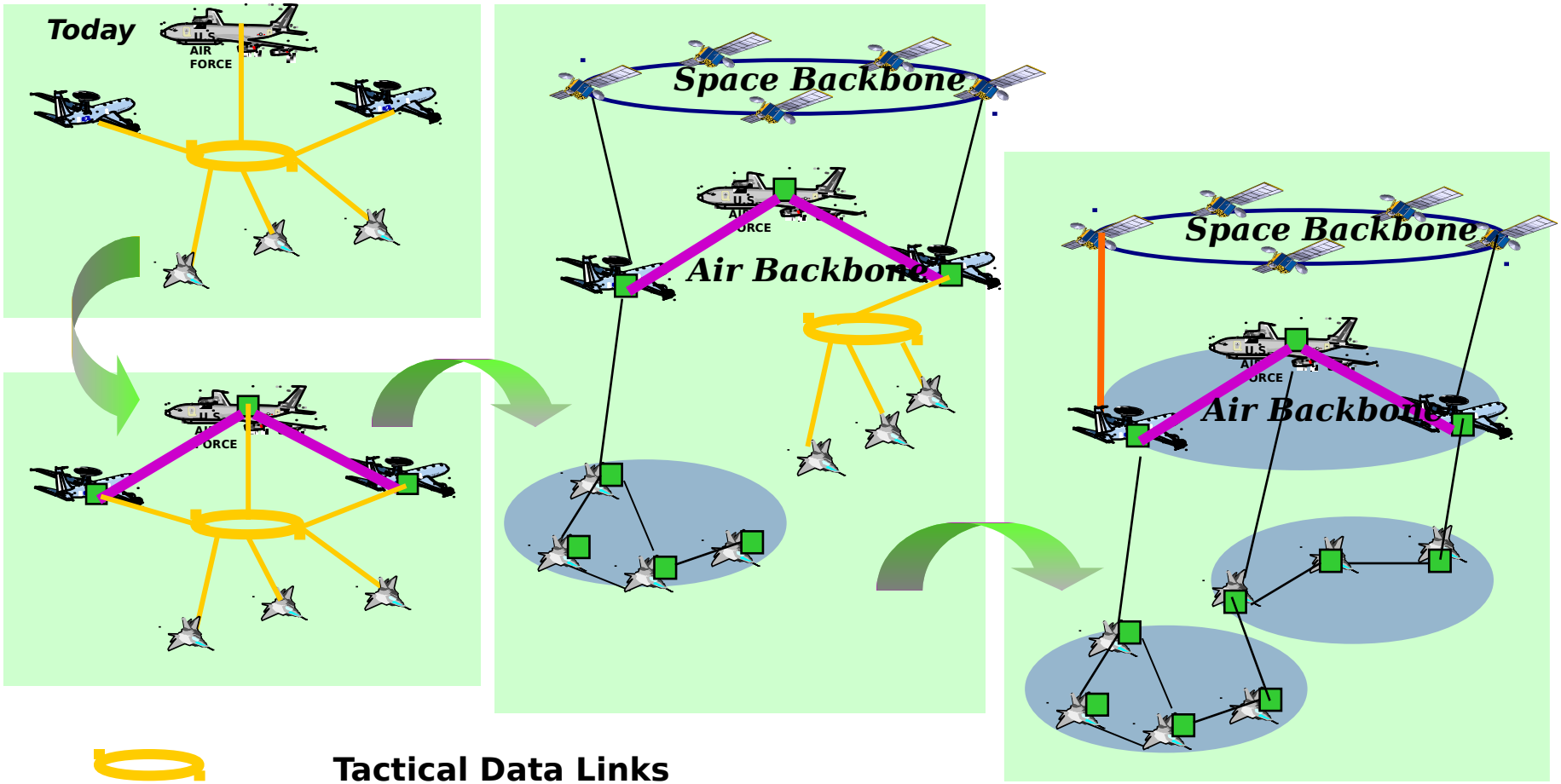
AN architecture will be realized through engineered evolution



Tactical Data Links

Wideband air-air links

Ad-hoc networks using Joint Tactical Radio System (JTRS) Networking Services

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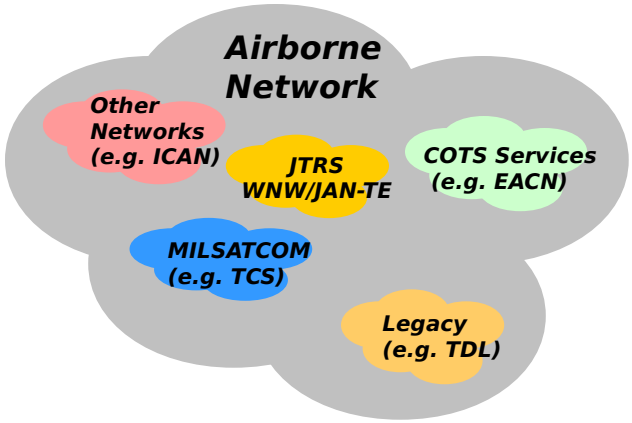
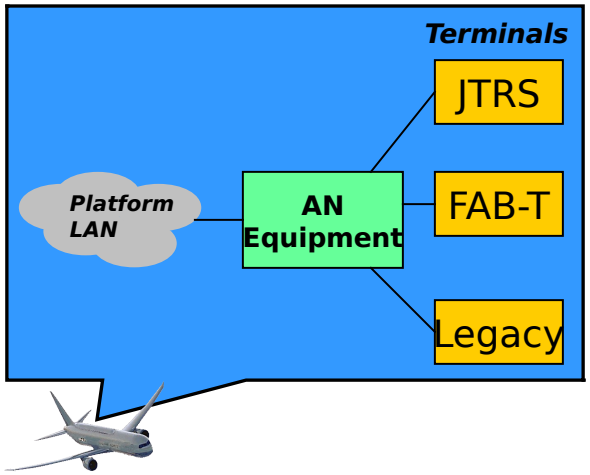
Airborne Network is more than a new link technology

Enterprise Networking Capability



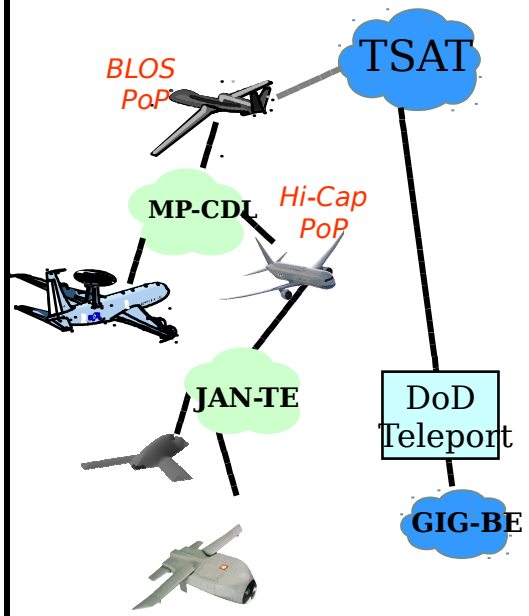
- **AN provides network connectivity as a network of networks**
- **AN provides not only network connectivity, but also IA, network management, network services (e.g., DNS) and network planning overlays**

Platform Capability



- **AN provides single network service delivery point for platforms with multiple radios**
- **AN provides guidance and standards for platform LAN implementations**
- **Potential for common product acquisition**

Infrastructure Capability



- **AN provides infrastructure products to extend network service**
- **AN provides standard packages for BLOS and/or Hi-Capacity Airborne Points-of-Presence**

Airborne Platforms Will Carry the Airborne Network Infrastructure

- **Every node is a potential routing node**
  - **Routing may be disabled on certain platforms when needed**
- **Frequently operating disconnected from the GIG and the enterprise infrastructure**
- **Platforms must carry most (maybe all) network management, information assurance, DNSs, and info directories**
- **AN capabilities are defined dynamically based upon the individual networking capabilities of each platform**
  - **Early AN implementations will be planned in detail**
  - **Future AN will be dynamically "compose-able"**

Overview

- Airborne Network Architecture
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- **Impact of Air-to-Air Link Performance**
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Assumptions Made for Internet Links Do Not Apply to AN Links

Link Attribute	Terrestrial Internet	Airborne Network	Networking Impacts
Bandwidth	Infinite – can add more fiber and routers as needed	Constrained by available spectrum in a geographic region Function of distance, antenna gain, power levels, interference	Routing performance
Bit Error Rate	10^{-9} to 10^{-12}, fairly constant	10^{-5} to 10^{-7}, highly variable due to distance, fading, EMI	End-to-end reliable transport
Stability	Generally long periods (days) of availability	Short periods (minutes, seconds) of availability the norm	Routing performance (convergence)
Threat	Generally few (e.g., backhoe)	Highly exposed to EMI and intentional jamming	Network capacity
Directionality	Bidirectional	May be unidirectional (e.g., different power levels)	Protocol algorithms

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- **Mobility Considerations**
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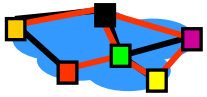
Subscribers and Infrastructure are in Motion

Changes in Subnet Composition

Platforms frequently joining and leaving subnets

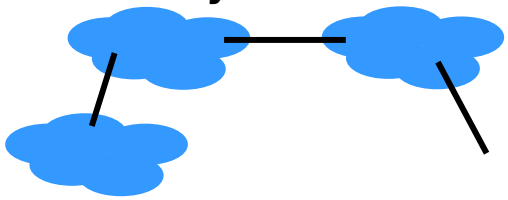
Platforms move from one subnet to another

Changes in Link Connectivity



Network topology changes – frequent link closures, breaks, new end points

Platforms change connectivity within a subnet

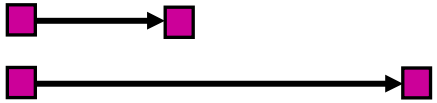


Subnets move and change their interconnection with other subnets

Changes in Link Performance

Link bandwidth

Bit error rates



Varying Latencies

Challenges of Mobility

- **Routing**
  - **New scalable routing algorithms having minimal overhead**
  - **New routing paradigms that do not require convergence**
  - **Direct use of link state information from smart radio terminals**
  - **Use of node state information, including geographic location, gathered through monitoring the local neighborhood**
- **Dynamic Management of Addresses**
  - **Assignment of addresses**
  - **Dynamic correlation of unique node identity to its current address**
- **Information Assurance**
  - **Discovery of red-side routers as black-side addresses change**
  - **Maintaining security associations as addresses change**

Overview

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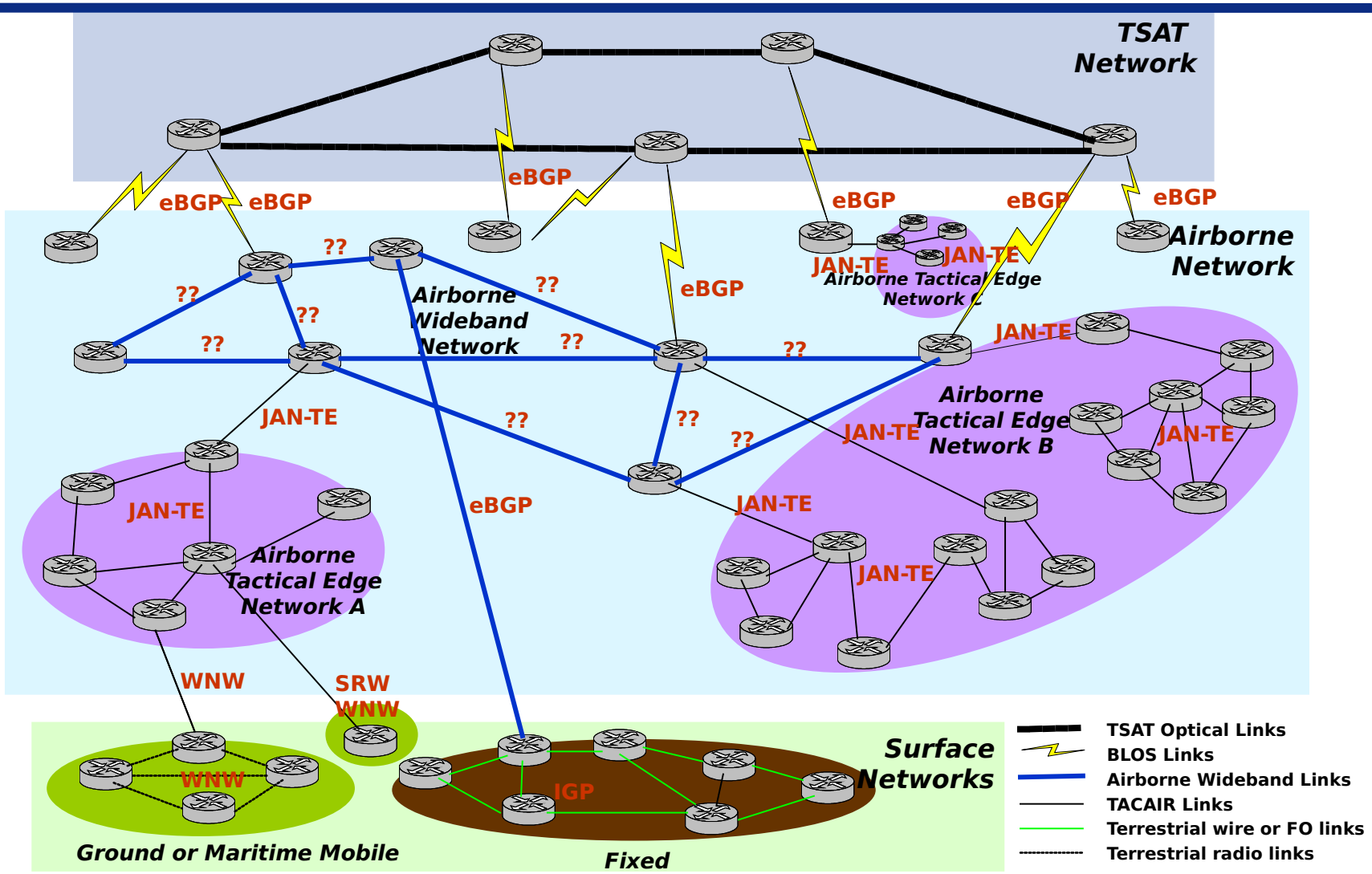
Integration of Mobile and Static Autonomous Systems - Routing



Integration Includes All Aspects of the Airborne Network

- **Network Management**
  - **Integration with NMs of other autonomous systems**
  - **Integration into higher-order management structures**
- **Information Assurance**
  - **End-to-end encryption, key management infrastructure**
  - **Public key infrastructure**
  - **Integrated attack sensing, warning, and response**
- **Network Services**
  - **Domain Name Servers**
  - **Network Directories**

Many of these areas are being addressed by OSD/NII's GIG End-to-end Working Groups

Summary

- **Assumptions made for the Internet do not apply to the Airborne Network**
  - **Airborne Network's infrastructure is dynamically "compose-able"**
  - **Link performance is extremely dynamic**
  - **Network composition and structure is very dynamic**
  - **No precedent for end-to-end integration of airborne networks with space and terrestrial networks**
- **Airborne Network cannot rely on a simple technology transfer from the Internet to satisfy all its requirements**

New networking concepts and paradigms are needed to address technology gaps